VI-AIM™/MI-AIM™ Alternating Input Module

Overview

In combination with VI-200 and VI-J00 Family modules and configured families of DC-DC converters, the Alternating Input Module provides a high density, low profile, universal AC input off-line switching power supply for systems requiring up to 200W of total output power. The VI-AIM accepts 85-264Vac, with a DC output voltage proportional to the peak value of the AC line. The input voltage required for the VI-AIM module to start operating is between 82V and 90Vrms (non-distorted).

Features of the VI-AIM

- Line Rectification
- EMC Filtering
- Transient Protection
- Inrush Limiting
- Surge Protection
- UL, CSA, TÜV Approval

The DC output of the VI-AIM is the peak rectified line ($Vac_{RMS} \times \sqrt{2}$), thus, 85Vac corresponds to 120Vdc and 264Vac corresponds to 373Vdc. Since the DC output range is wide, a “7” series DC-DC converter is normally used. However, the “5” series DC-DC converter is available for domestic AC inputs only and the “6” series for European AC inputs only, potentially reducing the number of modules required in some applications.

Summary of Compatible Modules

Use VI-x7x for inputs of 85-264Vac; VI-x6x for inputs of 170-264Vac; or VI-x5x for inputs of 85-135Vac. EMC filtering specifications of FCC level A are met by adding a 0.47 µF “X-type” capacitor to the input of the VI-AIM (Vicor Part #03047); “Y-type” bypass capacitors must also be added from the +/– inputs of the DC-DC converters to their respective baseplates, which are grounded (Vicor Part #00770, 1500 pF; Vicor Part #01000, 4700 pF). To select the capacitor appropriate for your application, (see *Selecting Capacitors for VI-AIM Modules* page 12-2).

The output ripple of the VI-AIM is a function of output load. It is necessary to keep the ripple less than 20V p-p to ensure the under/overvoltage protection circuits don’t trigger. A fully loaded VI-AIM (200W of module output power) requires a minimum of 680 µF of capacitance; holdup requirements can be met with this capacitor and maximum total capacitance should not exceed 1200 µF (refer to *Selecting Capacitors for VI-AIM Modules* on page 12-2). The voltage rating of this capacitor will be determined by the input operating voltage.

It is necessary to connect all DC-DC converter driver Gate In pins to the Gate In pin of the VI-AIM. This Gate In to Gate In connection is used to disable the converters at turn-on to allow proper start-up of the VI-AIM. The DC-DC converters are then enabled through the Gate In pin when the output bus voltage is in the range of 113-123Vdc. Input overvoltage conditions cause the Gate In pin of the VI-AIM to disable the converters when the output bus voltage is in the range of 406-423Vdc. Input undervoltage conditions cause the Gate In to disable the converters when the output bus voltage drops to 68-89Vdc.

CAUTION: The VI-AIM is not isolated. Do not put scope probes on input and output of VI-AIM simultaneously.

Summary of Compatible Modules (cont)

The Gate Out of the VI-AIM must be connected to the Gate Out of only one DC-DC converter. This input signal to the VI-AIM controls a charge pump (D1, D2, C2) that biases the gate of Q1, 10V above its source, which turns on Q1 to shunt out a PTC thermistor that limits inrush. Multiple DC-DC converters operating from an VI-AIM may make it impossible to guarantee a 10% load on the DC-DC converter that provides the Gate Out signal to the VI-AIM. In this instance, other DC-DC converters can charge pump the FET through the parallel pin, with the addition of two diodes and a capacitor to each driver module.

Figure 1. Block Diagram, VI-AIM

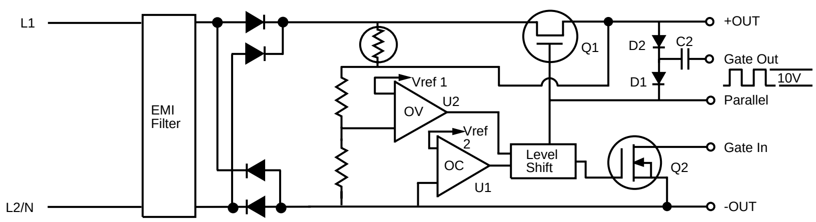
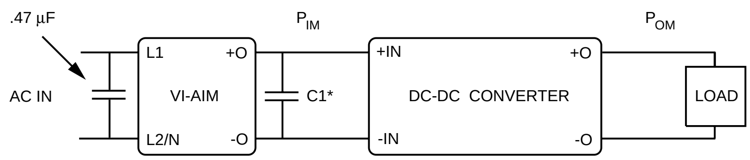


Figure 2. System Block Diagram (supervisory connections not shown)



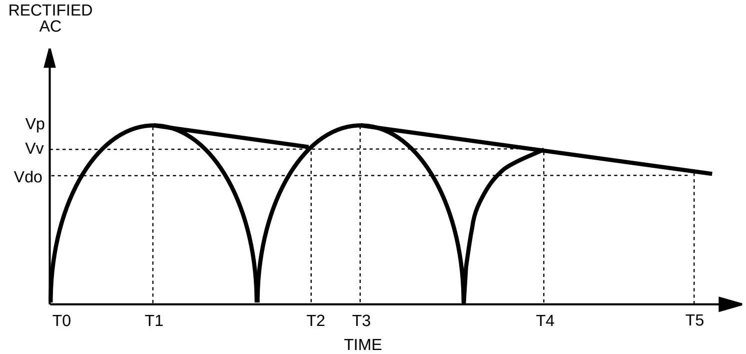
*C1 is a holdup capacitor necessary for proper operation of the VI-AIM. Holdup capacitors are available through Vicor Express.

Selecting Capacitors for VI-AIM

Holdup Time — General

For maximum flexibility, an external capacitor (Figure 2, C1) is used to set the system's holdup requirements. Holdup time, for purposes of this application note, is defined as the time interval from loss of AC power to the time a DC-DC converter begins to drop out of regulation (Figure 3, T4 to T5). Holdup time is a function of line voltage, holdup capacitance, output load, and that point on the AC waveform where the line drops out. For example, if the AC line fails just after the holdup capacitors were recharged, holdup time will be much greater (Figure 3, T3 to T5) than if the AC line fails just prior to another recharge (Figure 3, T4 to T5).

Figure 3. AC Waveforms



Selecting Capacitors for VI-AIM (cont)

The basic equations involved in calculating holdup time are:

$$\frac{1}{2} \times C1 \times V_p2 - \frac{1}{2} \times C1 \times V_{do}2 = P_{IM} \times (T5 - T3) \qquad (1)$$

solving for C1:

$$C1 = 2 \times \frac{P_{IM} \times (T5 - T3)}{V_p2 - V_{do}2} \qquad (2)$$

Where P_{IM} is power delivered from the VI-AIM:

$$P_{IM} = \frac{\text{Module Output Power}}{\text{Module Efficiency}} = \frac{P_{OM}}{\text{Eff }\%/100} \qquad (3)$$

The energy (Joules) delivered from the VI-AIM from the time power is lost (T4), until loss of an output (Figure 2, T5):

$$\text{Energy (Joules)} = P_{IM} \times (T5 - T4) \ \ (\text{Watt} - \text{Seconds}) \qquad (4)$$

where:
P_{OM} = Output power from all the modules
P_{IM} = Input power to the modules (output power from the VI-AIM)
Eff = Weighted average efficiency of all modules

The input power to the converter(s) during normal operation is supplied from the AC line during the conduction time of the rectifiers (T2 to T3) internal to the VI-AIM and by the energy stored in C1 when the rectifiers in the VI-AIM are reverse biased (T1 to T2). In the event of an AC failure (T4), C1 must continue to provide energy to the converters until either AC returns or the converter drops out (T5).

The energy stored in C1 at the peak of the AC is:

$$\frac{1}{2} \times C1 \times V_p2 = \text{Joules} \qquad (5)$$

The energy stored in C1 when the converter drops out of regulation is:

$$\frac{1}{2} \times C1 \times V_{do}2 = \text{Joules} \qquad (6)$$

The energy delivered by C1 to the converters during normal operation is:

$$P_{IM} \times (T2 - T1) = \text{Joules} \qquad (7)$$

Choosing Appropriate Values

Sample Calculation:

- Converter Output Power (P_{OM}) = 100W
- Line Frequency = 60 Hz
- Line Range = 105Vac to 264Vac
- Efficiency = 82%
- Desired Holdup Time = 5 ms Minimum

therefore:

- $P_{IM} = \frac{100}{0.82} = 122$ Watts
- T5 – T3 = 5 ms + 8.3 ms = 13.3ms (minimum holdup time plus half cycle)
- $V_p = 105 \times \sqrt{2} = 148V$
- $V_{do} = 100V$

and:

$$C1 = 2 \times \frac{122 \times .0133}{148^2 - 100^2}$$

C1 = 270 µF

where:

V_p = The peak of the rectified AC line or $\sqrt{2}$ x Vac_{in}. For an input range of 85 to 264Vac, this voltage will vary from 120V to 373V.

V_v = The low point of the rectified AC line under normal operating conditions. This “valley” voltage is a function of C1, P_{IM} and line frequency. The peak-to-peak ripple across C1 is Vp – V_v and determines the ripple current in C1. It is important to verify the rms ripple current in C1 with a current probe.

V_{do} = Voltage at which the DC-DC converter(s) begin(s) to drop out of regulation. This voltage is from the data sheet of the appropriate module, which for the VI-270 Family is 100Vdc. Under normal operating conditions,V_v must exceed V_{do}.

T1 = The peak of the rectified AC line or the point at which C1 is fully charged. For an input range of 85 to 264Vac, this voltage will vary from 120V to 373V.

T2 = The low point of the rectified AC line under normal operating conditions and the point at which C1 is about to be “recharged”. This is the point of lowest energy in C1.

T4 = The low point of the rectified AC line; the point of lowest energy in C1; the point at which if the AC line fails, holdup time is shortest, i.e., “worst case”.

T5 = The time at which the converter(s) drop out of regulation.

T5 – T4 = Minimum holdup time. Actual holdup time may vary up to a maximum of T5 – T3.

(T3 – T1) x 2 = One line cycle.

Choosing Appropriate Values (cont)

The following values are calculated in a similar manner:

Table 1.

Module(s)	60 Hz		50 Hz	
Delivered Power	90Vac	105Vac	90Vac	105Vac
50W	270 µF	135 µF	300 µF	150 µF
75W	400 µF	200 µF	440 µF	230 µF
100W	525 µF	270 µF	600 µF	300 µF
150W	800 µF	400 µF	890 µF	455 µF
200W	1000 µF	540 µF	1180 µF	600 µF

C1 values as a function of line voltage, frequency and delivered power, for use with 7-Series (90-264Vac) or 5-Series (90-132Vac) modules.

NOTE: With 7-Series modules operated over the line range from 90 to 264Vac, 400V capacitors **must be used** (Vicor P/N 08377). 5-Series modules used over the range of 90 to 132Vac should use 200V capacitors (Vicor P/N 08376).

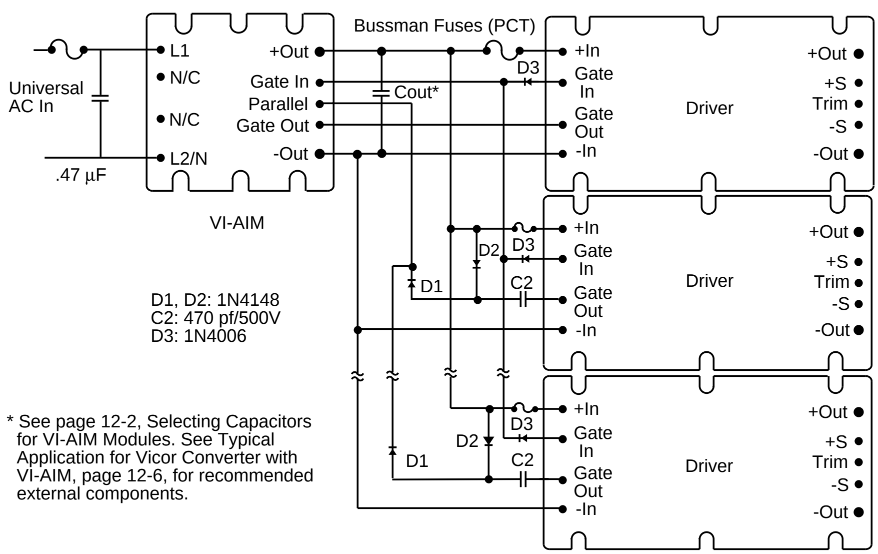
Table 2.

Module(s)	60 Hz		50 Hz	
Delivered Power	180Vac	210Vac	180Vac	210Vac
50W	66 µF	34 µF	74 µF	38 µF
75W	100 µF	50 µF	110 µF	60 µF
100W	130 µF	67 µF	150 µF	75 µF
150W	200 µF	100 µF	220 µF	115 µF
200W	262 µF	135 µF	300 µF	150 µF

Cl values as a function of line voltage, frequency and delivered power, for use with 6-Series (180-264Vac) modules.

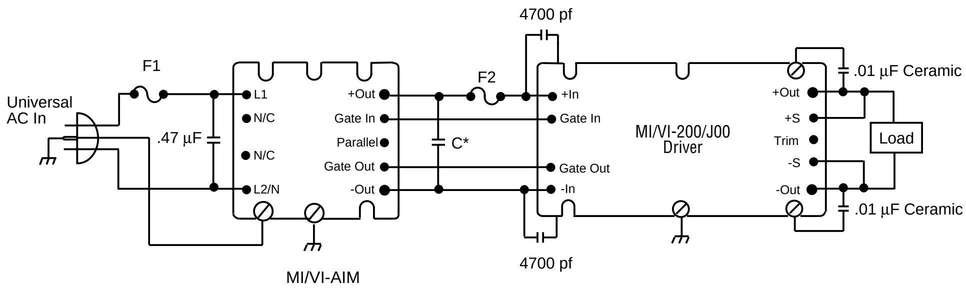
NOTE: With 6-Series modules operated over the line range from 180 to 264Vac, 400V capacitors **must be used** (Vicor P/N 08377).

Figure 4.
VI-AIM Connection Diagram, Multiple Driver Modules



Choosing Appropriate Values (cont)

Figure 5.
Typical Application for Vicor Converter with VI-AIM



* Consult factory or see Vicor's Applications Manual, page 12-2, Selecting Capacitors for VI-AIM Modules.

Fuse 1: 6.3A/250V (IEC 5X20 mm) Buss GDB-6.3 or 7A/250V (3AG 1/4" x 1 1/4") Littlefuse 314-007
Fuse 2: For VI-X7X-XX — Buss PC-Tron 2.5A (250V)
For VI-X6X-XX — Buss PC-Tron 3A (250V)
For VI-X5X-XX — Buss PC-Tron 5A